

## CLAIMS

What is claimed is:

1. An iterative carrier phase tracking decoding system comprising:
  - a buffer for buffering a block of symbols;
  - a serial turbo decoder for providing, during an iteration  $p$ , estimates  $s_k^p$  of one or more of the buffered symbols,  $r_k^p$ , and, optionally, one or more reliability metrics  $R_k^p$ , for the one or more estimates, and, after a prescribed number of iterations, estimates of underlying source bits;
  - a tracking loop module configured, during an iteration  $p$ , to (a) determine one or more residuals  $z_k^p$ , between the one or more buffered symbols,  $r_k^p$ , and the corresponding one or more symbol estimates,  $s_k^p$ ; (b) optionally weight the residuals with corresponding reliability metrics,  $R_k^p$ ; and (c) determine one or more derotation phases  $\theta_k^p$  responsive to one or more of the weighted or unweighted residuals;
  - a symbol derotator for derotating, during an iteration  $p$ , one or more of the buffered symbols,  $r_k^p$ , using the one or more derotation phases,  $\theta_k^p$ , and storing one or more of the derotated symbols,  $t_k^p$ , back in the buffer; and
  - a controller for directing the system to perform one or more iterations.
2. The system of claim 1 further comprising a delay element for compensating at least in part for delay through the serial turbo decoder and the tracking loop module.
3. The system of claim 1 wherein the serial turbo decoder comprises a series combination of an inner SISO, a de-interleaver, an output SISO, and an

interleaver, wherein the inner SISO has an a priori input coupled to the output of the interleaver.

4. The system of claim 3 wherein the inner and outer SISOs are soft  
5 output decoders.

5. The system of claim 4 wherein the decoders are log-MAP decoders.

6. The system of claim 3 wherein the symbol estimates are provided by  
10 the inner SISO of the serial turbo decoder.

7. The system of claim 3 wherein the symbol estimates are derived from  
the output of the interleaver of the serial turbo decoder.

8. The system of claim 7 wherein the symbol estimates are derived by  
15 passing the output of the interleaver through an encoder and channel symbol mapper  
that is configured to generate a code that the inner SISO is capable of decoding.

9. The system of claim 1 wherein one or more of the buffered symbols  $r_k^p$   
20 are derotated only during selected iterations.

10. The system of claim 1 wherein one or more of the buffered symbols  $r_k^p$   
are derotated after a prescribed number of iterations.

11. The system of claim 1 wherein one or more of the buffered symbols  $r_k^p$   
25 are derotated only during an initial number of iterations.

12. The system of claim 1 wherein the tracking loop module is configured to determine one or more of the derotation phases  $\theta_i^p$  in accordance with the following equation:

$$\theta_i^p = \sum_{j=i-W/2}^{j=i+W/2} z_j^p \cdot w_j$$

5 where  $\sum_{j=i-W/2}^{j=i+W/2} w_j = 1$ , W is the size of a window, in terms of number of symbols;

$z_j^p$  is a residual derived from a comparison of a buffered symbol  $r_j^p$  with a corresponding estimate of that symbol  $s_j^p$ ; and  $w_j$  is the weight assigned to the jth residual  $z_j^p$ .

10 13. The system of claim 12 wherein the weights  $w_j$  follow a time-domain description of a predefined phase-noise mask.

14. The system of claim 1 wherein the tracking loop module is configured to determine one or more of the derotation phases  $\theta_i^p$  in accordance with the following expression:

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$$\theta_i^p = \frac{\sum_{j=i-W/2}^{j=i+W/2} z_j^p \cdot w_j \cdot R_j^p}{\sum_{j=i-W/2}^{j=i+W/2} w_j \cdot R_j^p}$$

where W is the size of a window, in terms of number of symbols;  $z_j^p$  is a residual derived from a comparison of a buffered symbol  $r_j^p$  with a corresponding estimate of the symbol  $s_j^p$ ;  $w_j$  is the weight assigned to the jth residual  $z_j^p$ ; and  $R_j^p$  is a reliability metric for a symbol estimate  $s_j^p$ .

15. The system of claim 1 wherein the tracking loop module is configured to determine one or more derotation phases  $\theta_k^p$  in accordance with the following equation:

$$\theta_k^p = \sum_{i=1}^N a_i \cdot \theta_{k-i}^p + \sum_{i=0}^{M-1} b_i \cdot R_{k-i}^p \cdot z_{k-i}^p$$

5 where  $\theta_k^p$  is the derotation phase for the kth symbol during the pth iteration,  $\theta_{k-i}^p$  represents the derotation phase for the (k-i)th symbol during the pth iteration,  $a_i$  is a coefficient applied to  $\theta_{k-i}^p$ ,  $z_{k-i}^p$  is a residual derived from a comparison of a symbol  $r_{k-i}^p$  with an estimate  $s_{k-i}^p$  of that symbol,  $R_{k-i}^p$  is the reliability metric for the estimate of the (k-i)th symbol during the pth iteration,  $b_i$  is a coefficient applied to  $R_{k-i}^p \cdot z_{k-i}^p$ , and  
10 M and N are non-negative integers.

16. The system of claim 1 wherein one or more residuals  $z_k^p$  are phase residuals  $e_k^p$ .

17. The system of any of claim 1 wherein one or more residuals  $z_k^p$  are  
15 orthogonal component residuals  $y_k^p$  representing the components of  $r_k^p$  orthogonal to  $s_k^p$ .

18. A receiver including the system of claim 1.

20 19. A communications device including the receiver of claim 18.

20. A set-top box comprising the communications device of claim 19.

21. The system of claim 1 wherein the symbol derotator is a modulator.

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22. An iterative carrier phase tracking decoding system comprising:

buffer means for buffering a block of symbols;

serial turbo decoding means for providing, during an iteration  $p$ , one or more estimates  $s_k^p$  of one or more of the buffered symbols  $r_k^p$ , and, optionally, one or more reliability metrics  $R_k^p$ , for the one or more estimates, and, after a prescribed number of iterations, estimates of underlying source bits;

tracking loop means for, during an iteration  $p$ , (a) determining one or more residuals  $z_k^p$  between one or more of the buffered symbols,  $r_k^p$  and one or more corresponding symbol estimates,  $s_k^p$ ; (b) optionally weighting the one or more residuals with one or more corresponding reliability metrics,  $R_k^p$ ; and (c) determining one or more derotation phases  $\theta_k^p$ , responsive to one or more of the weighted or unweighted residuals;

symbol derotation means for derotating, during an iteration  $p$ , one or more of the buffered symbols,  $r_k^p$ , using one or more derotation phases,  $\theta_k^p$ , and storing one or more derotated symbols,  $t_k^p$ , back in the buffer; and

control means for directing the system to perform one or more iterations.

23. A method of performing iterative decoding, comprising the following steps:

providing one or more estimates  $s_k^p$  of a block of buffered symbols  $r_k^p$ ;

optionally providing one or more reliability metrics  $R_k^p$  for corresponding one or more estimates;

determining one or more residuals  $z_k^p$  between one or more buffered symbols  $r_k^p$  and one or more symbol estimates  $s_k^p$ ;

optionally weighting one or more residuals  $z_k^p$  with one or more reliability metrics  $R_k^p$ ;

determining one or more derotation phases  $\theta_k^p$  responsive to one or more of the weighted or unweighted residuals;

derotating one or more buffered symbols  $r_k^p$  using one or more derotation phases  $\theta_k^p$ ;

buffering one or more derotated symbols  $t_k^p$ ;

if a prescribed number of iterations has not been completed, performing  
5 another iteration beginning with the first providing step; and

after a prescribed number of iterations has been completed, providing estimates of underlying source bits.

24. The method of claim 23 further comprising derotating one or more buffered symbols  $r_k^p$  only during selected iterations.

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25. The method of claim 23 further comprising derotating one or more buffered symbols  $r_k^p$  after a prescribed number of iterations.

26. The method of claim 23 further comprising derotating one or more buffered symbols  $r_k^p$  only during an initial number of iterations.

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27. The method of claim 23 further comprising determining one or more derotation phases  $\theta_i^p$  in accordance with the following equation:

$$\theta_i^p = \sum_{j=i-W/2}^{j=i+W/2} z_j^p \cdot w_j$$

20 where  $\sum_{j=i-W/2}^{j=i+W/2} w_j = 1$ ,  $W$  is the size of a window, in terms of number of symbols;  $z_j^p$  is a residual derived from a comparison of a buffered symbol  $r_j^p$  with a corresponding estimate of that symbol  $s_j^p$ ; and  $w_j$  is the weight assigned to the  $j$ th residual  $z_j^p$ .

28. The method of claim 27 wherein the weights  $w_j$  follow a time-domain description of a predefined phase-noise mask.

29. The method of claim 23 further comprising determining one or more  
5 derotation phases  $\theta_i^p$  in accordance with the following expression:

$$\theta_i^p = \frac{\sum_{j=i-W/2}^{j=i+W/2} z_j^p \cdot w_j \cdot R_j^p}{\sum_{j=i-W/2}^{j=i+W/2} w_j \cdot R_j^p}$$

where  $W$  is the size of a window, in terms of number of symbols;  $z_j^p$  is a residual derived from a comparison of a buffered symbol  $r_j^p$  with a corresponding estimate of that symbol  $s_j^p$ ;  $w_j$  is the weight assigned to the  $j$ th residual  $z_j^p$ ; and  $R_j^p$  is a reliability  
10 metric for the symbol estimate  $s_j^p$ .

30. The method of claim 23 further comprising determining one or more derotation phases  $\theta_k^p$  in accordance with the following equation:

$$\theta_k^p = \sum_{i=1}^N a_i \cdot \theta_{k-i}^p + \sum_{i=0}^{M-1} b_i \cdot R_{k-i}^p \cdot z_{k-i}^p$$

where  $\theta_k^p$  is the derotation phase for the  $k$ th symbol determined during the  $p$ th  
15 iteration,  $\theta_{k-i}^p$  represents the derotation phase for the  $(k-i)$ th symbol during the  $p$ th iteration,  $a_i$  is a coefficient applied to  $\theta_{k-i}^p$ ,  $z_{k-i}^p$  is a residual derived from a comparison of a symbol  $r_{k-i}^p$  with an estimate  $s_{k-i}^p$  of that symbol,  $R_{k-i}^p$  is the reliability metric for the estimate of the  $(k-i)$ th symbol during the  $p$ th iteration,  $b_i$  is a coefficient applied to  $R_{k-i}^p \cdot z_{k-i}^p$ , and  $M$  and  $N$  are non-negative integers.

20 31. The method of claim 23 wherein one or more residuals  $z_k^p$  are phase residuals  $e_k^p$ .

32. The method of claim 23 wherein one or more residuals  $z_k^P$  are orthogonal component residuals  $y_k^P$  representing the components of one or more of the buffered symbols  $r_k^P$  orthogonal to corresponding one or more estimates  $s_k^P$ .

5      33. A computer readable medium tangibly embodying the steps of any of the methods of claims 23-32.

34. The medium of claim 33 which is a memory.

10      35. Circuitry embodying the steps of any of the methods of claims 23-32.

36. The circuitry of claim 35 in a decoder.

15      37. A synthesized logic circuit which comprises the circuitry of claim 36.

38. An integrated circuit which comprises the circuitry of claim 36.

20      39. A method of performing iterative decoding, comprising the following steps:

        a step of providing one or more estimates  $s_k^P$  of one or more buffered symbols  $r_k^P$ ;

        a step of optionally providing one or more reliability metrics  $R_k^P$  for one or more estimates;

25      a step of determining one or more residuals  $z_k^P$  between one or more buffered symbols  $r_k^P$  and corresponding one or more symbol estimates  $s_k^P$ ;



a step of optionally weighting one or more residuals  $z_k^p$  with one or more corresponding reliability metrics  $R_k^p$ ;

a step of determining one or more derotation phases  $\theta_k^p$  responsive to one or more of the weighted or unweighted residuals;

5 a step of derotating one or more buffered symbols  $r_k^p$  using one or more derotation phases  $\theta_k^p$ ;

a step of buffering one or more derotated symbols  $t_k^p$ ;

if a prescribed number of iterations has not been completed, a step of performing another iteration beginning with the first providing step; and

10 after a prescribed number of iterations has been completed, a step of providing estimates of underlying source bits.

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